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DIFFERENCES AND CORRELATIONS

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BY TRUMAN LEE KELLEY

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THE ASSOCIATION EXPERIMENT: INDIVIDUAL DIFFERENCES AND CORRELATIONS¹

BY TRUMAN LEE KELLEY

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This paper deals with the correlation of certain laboratory tests in association, with class standings in mathematics, science and foreign languages.

The association experiment used was by a somewhat more complete method than the ordinary free association experiment in that complete introspections were recorded.

The following 100 words were used as stimulus words:

- | | | |
|--------------|---------------|----------------|
| 1. arch | 26. bar | 51. secure |
| 2. prude | 27. president | 52. giggle |
| 3. egotism | 28. fluster | 53. inhuman |
| 4. single | 29. juicy | 54. ecstasy |
| 5. chastity | 30. death | 55. lace |
| 6. ginger | 31. press | 56. hint |
| 7. shrew | 32. beauty | 57. blush |
| 8. adapt | 33. retard | 58. wicked |
| 9. tough | 34. ghostly | 59. conscience |
| 10. morality | 35. future | 60. shoulder |
| 11. rubber | 36. text | 61. graft |
| 12. coquet | 37. success | 62. behave |
| 13. kick | 38. abstract | 63. sacrifice |
| 14. forward | 39. fatalism | 64. philosophy |
| 15. truth | 40. gauze | 65. trifle |
| 16. cake | 41. error | 66. bedlum |
| 17. skeptic | 42. gargle | 67. consent |
| 18. extort | 43. energetic | 68. courage |
| 19. modest | 44. apathy | 69. cowardice |
| 20. religion | 45. silk | 70. course |
| 21. knife | 46. stage | 71. habit |
| 22. fanatic | 47. curse | 72. gamble |
| 23. insult | 48. duty | 73. purity |
| 24. flaxen | 49. valor | 74. drug |
| 25. soul | 50. velvet | 75. snake |

¹ This experiment was conducted at the University of Illinois in 1911 and the complete data, including a record of the 1,200 introspections, is to be found on file in the library of the university.

76. intention	84. temperance	92. quitter
77. caution	85. chide	93. thrill
78. alimony	86. law	94. character
79. atheism	87. virtue	95. thief
80. cuckoo	88. reverse	96. guile
81. height	89. handsome	97. bully
82. deject	90. temper	98. revel
83. concept	91. heaven	99. revenge
		100. iniquity

It will be noticed that a very generous proportion of them are more or less abstract in their nature. These abstract words were chosen with the aim of bringing out significant modes of reaction, which it was thought they would accomplish more readily than concrete and less difficult words. The remainder are intended to represent a random sampling of the words used in ordinary life.

The instructions to the observers were that upon hearing one of these stimulus words they were to react with the first word that came to mind. They were told that no logical relation between stimulus word and reaction word was demanded—the only requirement being that the reaction word must be one suggested in some manner by the stimulus word.

The time between stimulus word and reaction was measured by means of a stop watch, operated by the experimenter. The watch was read to 10ths of a second by estimation between 5ths of a second divisions and was started and stopped by the armature of an electric magnet which was in circuit with an easily operated key. This arrangement proved more precise than could be obtained by manipulating the watch directly. A series of tests to determine the probable error in the time of observation due to the experimenter's manipulation showed it to be slightly less than .1 second, *i. e.*, his average deviation in measuring a stimulus of known duration was about .1 second. The time between the end of the stimulus word and the beginning of the reaction word is taken.

After the reaction the observer was asked for a complete introspection concerning the association process and a shorthand record of this account was taken. (The entire data

for this experiment comprising some 80 closely written pages are too bulky to incorporate in this article.) The data are classified according to three schemes. (The detailed classification is likewise omitted having little significance separate from the original data.)

1. All the associations which the introspections showed referred to some particular situation are classed in a *Particular Situation* class. All other associations are put into a *General Situation* class. The reference to a particular situation is shown by the visual imagery or other thought process being a memory of some specific circumstance. The following are illustrations of this class: The association of Observer E, No. 5, was as follows: stimulus 'chastity,' reaction 'pure,' introspection "I thought of one of Shakespeare's plays. The class discussed the character of the play and the purity of the heroine. Visual image of the page in the book dealing with this." Another illustration: Observer I, No. 23—stimulus 'insult,' reaction 'offence,' introspection "The idea came from having recently heard Ex-Governor Glenn, who spoke about the insult to the white population. He seemed to pronounce the word as though it were 'insulu-it.'"

2. The data are classified according to the imagery involved, using the following seven subdivisions: *Articulatory*; *Visual*; *Kinesthetic*; a *General* group composed of *Olfactory*, *Gustatory*, *Cutaneous*, *Auditory* and *Organic*; *Second Articulatory* (by which is meant that the reaction word is one that had occurred at least once before in the series); *Second Visual* (by which is meant that the visual imagery is the same as that called up by some preceding word); *No Imagery*. In a very considerable number of observations, more than one kind of imagery was involved. In such cases as many different kinds of imagery were credited with the reaction as the introspection showed to be present. The reliability of these different classes differs greatly. The first class, *Articulatory Imagery*, is very unreliable for the reason that most of the observers, although advanced students of psychology, were uncertain as to the criteria of articulatory imagery. This was equally true of kinesthetic, olfactory, gustatory, cutane-

ous, auditory and organic imagery. It is not the case with visual imagery; here the introspections are definite and in only a few cases does the observer show doubt as to the existence or non-existence of visual imagery. The *Second Articulatory* class is exact, depending entirely upon the previous use of the reaction word. In explaining his introspections the observer very generally used the stimulus word and necessarily thought it in all cases. For this reason in later reactions, if the reaction word previously occurred as a stimulus word the association was classed under *Second Articulatory*. The *Second Visual* class proved so small that it need not be considered. The *No Imagery* class is a small one, comprising only those reactions in which the observer definitely denied the presence of imagery. If the introspection contains no statement at all in regard to the imagery the association is put into the Articulatory class, thus further tending to make the class unreliable. The only two classes considered accurate for the purpose of this study are the *Visual* and *Second Articulatory*.

3. A classification according to the nature of the mental process involved in association is used. It is a modification of the classification used by Wells¹ and consists of the following 15 classes: (1) Sound; (2) Phrase Completion; (3) Synonyms; (4) Contrast; (5) Coexistence; (6) Predicate and Judgment of Quality; (7) Subordination; (8) Coördination; (9) Supraordination; (10) Egocentric; (11) Egocentric Predicate; (12) Subject Relation; (13) Object Relation; (14) Causality; (15) Failure. An explanation in some detail will be necessary to indicate just what is put into each class and the lines of demarcation between the classes. The classification is a purely arbitrary one and there is no natural line of division between classes, but that fact does not in itself destroy the usefulness of the classification if it is possible to measure the degree of relation between the classes and thus utilize their interdependence. A further discussion of this point is given later in describing the method of grouping. The following principles are followed in the classification of the data:

¹ *American Journal of Psychology*, January, 1909.

1. Class 1 comprises those associations in which the sound of the word played the leading part, as in the following: Observer *D*, No. 49, stimulus 'valor,' reaction 'vanity,' introspection "A sound reaction. After reacting the meaning came as 'bravery.'" Associations in which the reaction word is some modified form of the stimulus word are also found in this class, *e. g.*, observer *D*, No. 64, stimulus 'philosophy,' reaction 'philosopher.' There is little difficulty in determining the associations which belong to this class, though occasionally an uncertainty arises, *e. g.*, stimulus 'man,' reaction 'mankind' might properly be either in this class, the class Supraordination, or the class Phrase Completion. This difficulty is not serious, as the introspections almost invariably indicate to which class such a reaction belongs. The difficulty in distinguishing between class 2 and class 1 is slightly greater than that between any of the other classes and class 1.

2. Class 2 is comprised of those reactions in which a word (in case the stimulus is the first part of a compound word), a phrase, or an idea, is completed by the addition of another word or words. Such a reaction as the following: stimulus 'text,' reaction 'text-book' is put into this class, though it does not differ much from the following: stimulus 'man,' reaction 'mankind,' which would have been put into Class 1. Another illustration of a reaction put into this class is the following: stimulus 'shrew,' reaction 'Taming of the Shrew,' introspection "I thought of the play 'Taming of the Shrew' in articulatory terms." This class is not as clearly defined as the first, conflicting more or less with most of the other classes. Illustrations of the conflict with the different classes are readily available—the following is one: stimulus 'black,' reaction 'white,' introspection "I thought of the phrase 'black and white.'" Whether this belongs here or in Contrast is a question. If the phrase were 'black and blue' it would have been put into this class. The Phrase Completion class especially competed with the Subject Relation and Object Relation classes in its claim for certain reactions, *e. g.*, observer *D*, No. 88, stimulus 'reverse,' reaction 'engine,'

introspection "Clear visual image of the throttle of an engine." This quite clearly belongs in the Object Relation class, but if the introspection had been "I thought of the phrase 'reverse the engine,'" the reaction would have belonged in the Phrase Completion class. In a number of cases the introspections do not clear up the difficulty. It is felt by the writer that the distinction between the Phrase Completion class and the Subject Relation and Object Relation classes is particularly indefinite.

3. The Synonym class is composed of those cases in which the reaction word is more or less accurately a synonym of the stimulus word. The Identity, or Synonym, class gradually grades into the Coexistence class or the Coördination class. However, if a word might equally well be put into the Coexistence or Synonym class, it was always put into the latter.

4. The Contrast class is composed of those reactions showing contrast between stimulus and reaction word, and also of certain reactions in which the introspection shows plainly that the idea of contrast is present, though the stimulus and reaction words do not show it, *e. g.*, observer *I*, No. 69, stimulus 'cowardice,' reaction 'fight,' the introspection giving as the idea, that the opposite of cowardice—courage—can be shown only by a fight. As the idea of contrast between stimulus and reaction is less and less pronounced this class grades imperceptibly into the class Coördination. It is also related to Coexistence since a large number of contrasting ideas are also coexisting. If the contrast is not a perfect one there may be a question whether the association belongs in the Contrast or one of the classes Subordination, Supraordination. This latter difficulty did not prove a very general one.

5. The Coexistence class is a very general class. It is related to all the other classes, though it was not credited with any reaction that could be put into any other one. When the reaction word is quite apparently related in some way to the stimulus word, but in so obscure a way that it cannot be said to be a relation of Identity, Contrast, etc., the association is classified here. In certain of the reactions

of this class the stimulus and reaction words represent things which coexist in nature, and in certain others the stimulus and reaction words represent two ideas which coexist only in the realm of thought.

6. In the beginning of the classification it was attempted to distinguish between a simple predicate and a judgment of quality, but the two classes so nearly approached identity in the mind of the classifier that it was abandoned and in the following discussion the two classes are grouped as a single Predicate class. There are two main types of association in this class: (*a*) those in which some object is named as the stimulus and a predicate of it given as the reaction word, and (*b*) those in which a predicate is named and some object given to which this predicate is appropriate. A reaction such as the following would be put into this class; stimulus 'beauty,' reaction 'girl.' It is thought that such a stimulus is taken either as 'beautiful' or immediately suggests it, making the association of the genuine predicate type.

7 and 9. The classes Subordination and Supraordination may be easily separated by arbitrarily saying that such a reaction as the following; stimulus 'horse,' reaction 'animal,' shall be put into the Supraordination class and a reaction; stimulus 'animal,' reaction 'horse,' shall be put into the Subordination class, and such has been the method here used, but an attempted analysis of the thought processes involved by no means yields such a clear-cut distinction. The Predicate and Subordination classes seem related since the mental process of attaching a specific example to a larger class is quite analogous to that of attaching a predicate to an object. For a similar reason the Predicate and Supraordination classes seem related.

8. The Coördination class is arbitrarily limited to cases in which the stimulus word and reaction word are of equal logical value, unless the introspection shows in some other case that the coördination idea is present, *e. g.*, it is of course quite possible that the idea of coördination may be present when stimulus and reaction words are as different as the following; stimulus 'beauty,' reaction 'man'—in such a case

the introspection might reveal that the idea was of a 'beautiful woman' and a 'handsome man.' The relation between Coördination and Synonyms, and Contrast, has been discussed under those topics.

10 and 11. The class Egocentric contains only eight observations and the class Egocentric Predicate contains none at all, hence the discussion of these classes will be omitted. It is quite possible that they might be of very considerable size with different observers.

12 and 13. The Subject Relation class is comprised of two kinds of reactions: (*a*) those in which the stimulus word is a verb and the reaction word the subject of it, and (*b*) those in which the stimulus word is a noun, conceived of as the subject of the reaction word, which is a verb. Similarly there are two kinds of reactions put into the Object Relation class. The similarity between these classes and the Phrase Completion class has already been noted. The number of observations in these two classes is small.

14. Causality is a very limited class and comprises those reactions in which the stimulus represents the cause of the reaction word, or vice versa. The following is an illustration; observer *E*, No. 23, stimulus 'insult,' reaction 'man,' introspection "Hazy visual image of a man coming along the sidewalk and shoving a lady over to one side." The illustration cited shows the close connection between this class and the Subject Relation and Object Relation classes.

15. The Failure class is composed of two kinds of reactions: (*a*) those in which there is a blocking of the association processes and a corresponding inability to react, and (*b*) those in which the reaction, though set off by the stimulus word, has no connection with it and is, in reality, a reaction to an ideational process inaugurated by the observer entirely independent of the stimulus word. Very few reactions of this nature occurred, and in fact the entire class is small.

Following is a table showing the more important elements of the complete classification.

Observers	Reaction Time	Variability	Particular Situation	Visual Imagery	Second Articulatory
A.....	1.38	.32	20	74	16
B.....	1.03	.20	43	70	6
C.....	1.34	.50	6	5	3
D.....	1.44	.89	5	33	3
E.....	1.71	.43	49	57	8
F.....	1.40	.30	9	38	9
G.....	1.20	.30	30	71	7
H.....	1.34	.30	4	41	7
I.....	1.44	.33	49	48	3
J.....	1.27	.38	6	62	13
K.....	1.06	.24	8	82	43
L.....	1.64	.35	22	56	4

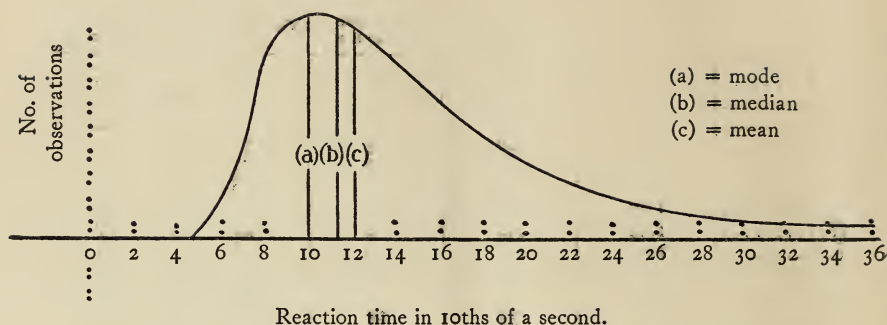
	Sound	Phrase Comp.	Synonyms	Contrast	Coex.	Pred.	Subor.	Coör.	Supra.	Egoc.	Subj. Rel.	Obj. Rel.	Causal	Failure	
A	4	9	21	2	11	36	8	4	0	4	1	0	0	0	A
B	2	14	4	3	14	43	5	6	6	0	1	1	1	0	B
C	1	15	49	0	9	14	3	0	1	0	1	0	3	4	C
D	36	9	19	4	5	8	3	3	2	0	0	1	0	10	D
E	12	8	11	2	17	24	4	5	5	0	3	5	2	2	E
F	2	28	25	11	11	10	1	3	1	0	2	1	4	1	F
G	3	8	22	1	23	18	14	0	0	0	2	3	5	1	G
H	3	9	28	5	12	18	5	3	1	3	3	3	4	3	H
I	6	6	33	13	12	5	3	8	5	0	0	3	2	4	I
J	2	7	31	16	5	12	2	12	1	0	1	2	4	5	J
K	4	12	3	1	12	30	2	2	10	0	8	9	3	4	K
L	7	17	14	4	12	16	4	6	5	1	5	3	5	1	L
	82	142	260	62	143	234	54	52	37	8	27	31	33	35	

In this table the measure of the reaction time, appearing in the second column, is the median. One half the difference between the upper and lower quartiles (the semi-quartile difference) is given as the measure of variability. In the remaining columns the figures given indicate the number of reactions put into these classes.

REACTION-TIME MEASURES

The use of the median instead of the mean as the best measure of reaction time is based upon the fact that there is a skew distribution of reaction times, represented by a curve such as shown on the following page.

The mode and mean are on opposite sides of the median, the mode being closer to the short time reaction end and the mean closer to the long time reaction end of the distribution curve. One factor tending toward such a skew dis-



tribution lies in the existence of a number of reactions in which there is a blocking or conflict in the mental process, thus excessively lengthening the reaction time. If this factor could be entirely eliminated it is still probable that there would be a skew distribution since there is an absolute lower limit, less than which the reaction time cannot be, but no such upper limit. With such a skew distribution the average is too greatly affected by a few large observations to make it a desirable measure of reaction time. Again, the mode takes no account whatsoever of any measures except those neighboring to it and is therefore not a desirable measure. The median is affected to an equal extent by every measure and is here considered the best single value to measure the reaction time of the individual. The same objection that applies to the mean applies to such measures as the average deviation, or the standard deviation, as measures of variability, and for the same reason that the median is chosen as the best measure of reaction time, the semi-quartile difference is chosen as the best measure of variability.

GROUPING OF CLASSES

In the classification according to the nature of the mental process involved there are fifteen classes, with varying numbers of observations in each. In order to have measures of the types of reaction which are more reliable than is possible under such conditions certain of these classes have been combined into groups. There are at least two methods for determining the classes which shall be so combined.

1. The combination of the classes into groups according to the judgment of the classifier, his idea as to the intimacy of the classes being the sole justification for combining them. Instead of adopting such a method, which would be simply an *a priori* judgment on the part of the classifier, the following is used:

2. The observers are ranked according to the total number of observations occurring in one class and then ranked again according to the total number occurring in a second class. With these rankings as a basis the degree to which the two classes are correlated determines whether the classes are grouped or not. In a similar manner every class was correlated with every other class. We may well assume a similarity of mental process to be involved in reacting according to the different classes so grouped. The following table shows the correlation existing between each class and certain of the other classes:

	Sound	Phrase Comp.	Synonyms	Contrast	Coex.	Predicate	Subor.	Coör.	Supra.	Causal	Subj. Rel.
Sound.....	I.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phrase Comp.....	-.28	I.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Synonyms.....	-.75	-.37	I.	.....	.....	.....	.....	.....	.....	.....	.....
Contrast.....	.....	.....	.44	I.	.....	.....	.....	.....	.....	.....	.....
Coexist.....	.31	.....	-.37	.....	I.	.....	.....	.....	.....	.....	.....
Predicate.....	.....	.....	-.55	-.55	.60	I.	.....	.....	.....	.....	.....
Subor.....	.....	.....	.....	-.34	.55	.55	I.	.....	.....	.....	.....
Coör.....	.....	.....	.09	.69	.....	.....	.....	I.	.....	.....	.....
Supra.....	.31	.....	-.69	.....	.34	.....	.....	.47	I.	.....	.....
Causality.....	-.34	.....	.....	.....	.....	.....	.....	-.44	-.55	I.	.....
Subj. Rel.....	.....	.....	-.47	.....	.41	.55	.....	.....	.28	.47	I.
Obj. Rel.....	.50	-.28	-.38	.....	.57	.....	.....	.....	.57	.28	.62

The method of calculating these coefficients of correlation and their probable errors, which is .19 or less, is given later. In any square in the table the coefficient of correlation found is that between the classes indicated at the top of the column and the left of the row in which the coefficient occurs. Those squares left blank indicate that the correlation is small, in fact in no case larger than one and one third times the probable error. An inspection of this table shows that certain classes may be combined into groups on the basis of high correlation between them.

(Alpha) Synonyms, Coördination and Contrast are combined into a single group, Alpha, on account of the following correlations; between Synonyms and Contrast, .44; between Contrast and Coördination, .69. The positive correlation between Synonyms and Coördination, .09, is so small as to be practically no additional reason for the grouping.

(Beta) Object Relation, Subject Relation and Causality are combined into a single group, Beta, on the basis of the following correlations; between Object Relation and Subject Relation, .62; between Subject Relation and Causality, .47; and between Causality and Object Relation, .28.

(Gamma) Predicates, Subordination and Coexistence are combined into a single group, Gamma, on the basis of the following correlations; between Predicates and Coexistence, .60; between Coexistence and Subordination, .55; and between Subordination and Predicates, .55.

The following classes are not grouped: Phrase Completion, Sound, Supraordination. Phrase Completion shows no decided positive correlations. Sound is appreciably correlated with Object Relation, but not with the subjects Causality and Subject Relation, which are highly correlated with Object Relation, and therefore Sound is not grouped with Object Relation. For a similar reason Supraordination is not grouped. Coexistence is not classed with the subjects in group Beta for it is more highly correlated with the subjects, Predicates and Subordination, with which it has been grouped.

The positive correlation coefficients here given are somewhat too small and the negative coefficients too large for the reason that there is a tendency toward negative correlation, since the more in one class the less number that remain which can be put into another class. After a reaction is put into one class there is less probability, in the ratio of 99 to 100, of any other class containing as great a number as it otherwise would. For this reason the importance of negative correlation coefficients lies in their ability to indicate which classes are most strongly opposed, rather than to accurately measure the amount of opposition.

Following is a table giving the number of times the observers reacted according to the Alpha, Beta and Gamma types:

	Alpha	Beta	Gamma
A.....	27	1	55
B.....	13	3	62
C.....	49	4	26
D.....	26	1	16
E.....	18	10	45
F.....	39	7	22
G.....	23	10	55
H.....	36	10	35
I.....	54	5	20
J.....	59	7	19
K.....	6	20	44
L.....	24	13	32

This table is obtained by combining the appropriate columns of the table on page 487.

The complete record of introspections makes it possible to investigate what effect the elaborateness of the association process has upon the reaction time. This is done in the following manner:

In addition to the three schemes of classification already mentioned the data are classified according to the number of ideas or the number of different kinds of imagery present in each association, as shown by the introspections. Each association is given a grade for its elaborateness, 1, 2, 3, etc., which is based upon the number of discrete ideas or different kinds of imagery present, *i. e.*, if the introspection shows but a single idea and but a single kind of imagery then the association is graded 1. If the introspection shows one idea, but expressed through two kinds of imagery, or two ideas, sufficiently separate from each other to warrant being called two discrete ideas, expressed through but one kind of imagery, then the grade is 2, and similarly for grades 3 or 4. The determination of the number of ideas and, to a less extent, the determination of the different kinds of imagery is only approximately possible, but only a relative determination of the elaborateness of the associations is sought and, so far as external criteria can determine this fact, the introspections and the scheme of grading adopted probably answer the

purpose fairly well. Although the associations are here put into 1 idea, 2 ideas, etc., classes, it is not to be supposed that associations naturally divide themselves into such classes and that there are not as well associations of an elaborateness corresponding to the grades $1\frac{1}{2}$, $1\frac{3}{4}$, $2\frac{1}{3}$, etc.

It is to be noted that the classification according to the number of ideas or kinds of imagery is entirely irrespective of whether these ideas or different kinds of imagery are consecutive or simultaneous. In some cases the introspections reveal a train of thought composed of three or four ideas, but more frequently they reveal simply a number of ideas and kinds of imagery, which may have been either simultaneous or in the form of a train. The possibility of having two separate simultaneous ideas is neither affirmed nor denied—the position is that the introspections, in the majority of cases, where more than one idea is present, do not reveal whether one idea has arisen after the other or whether the two or more ideas are simply different aspects of a single state of consciousness.

All the reactions are classified as indicated, after first discarding those in which the observer distinctly indicated that there had been a blocking or conflict in the thought processes. The following table gives the number of observations in each class, the median reaction time and the upper and lower quartiles.

A reference to the median values shows that there is approximately an increase of .14 second between any class and the one above it. The significance of this increase is apparent when compared with some measure of deviation, *e. g.*, the semi-quartile difference, which, from the last column in the above table, we find to be .31 second. That is, there is an increase of $14/31$ of the median deviation for each additional idea or kind of imagery present in the association. Even this measure, *viz.*, $14/31$ of the median deviation, is difficult of entirely significant interpretation.

The most adequate measure to interpret linear relation is a coefficient of correlation. The data being here considered are not entirely satisfactory for correlation purposes for the

	One Idea	Two Ideas	Three or More Ideas	Total
No. observations.....	23	39	23	85
A: L. Q.....	1.2	1.0	1.4	1.15
M.....	1.4	1.2	1.6	1.3
U. Q.....	1.6	1.4	2.0	1.6
No. observations.....	33	38	14	85
B: L. Q.....	.9	.8	.9	.9
M.....	1.0	1.0	1.1	1.0
U. Q.....	1.0	1.1	1.23	1.15
No. observations.....	74	13	.....	87
C: L. Q.....	1.0	1.35	.....	1.0
M.....	1.18	1.8	.....	1.2
U. Q.....	1.63	2.15	.....	1.7
No. observations.....	44	28	4	76
D: L. Q.....	1.0	1.0	1.28	1.0
M.....	1.15	1.2	2.3	1.2
U. Q.....	1.73	1.68	3.03	1.8
No. observations.....	23	50	20	93
E: L. Q.....	1.3	1.4	1.4	1.3
M.....	1.4	1.7	1.65	1.6
U. Q.....	2.0	2.08	2.28	2.1
No. observations.....	64	28	5	97
F: L. Q.....	1.2	1.23	1.0	1.2
M.....	1.3	1.55	1.1	1.4
U. Q.....	1.68	1.9	1.4	1.8
No. observations.....	69	23	6	98
G: L. Q.....	.8	1.1	1.15	.9
M.....	1.1	1.4	1.5	1.2
U. Q.....	1.4	1.9	1.93	1.5
No. observations.....	44	38	10	92
H: L. Q.....	1.0	1.1	1.13	1.0
M.....	1.2	1.3	1.5	1.3
U. Q.....	1.4	1.5	1.78	1.5
No. observations.....	59	28	6	93
I: L. Q.....	1.1	1.23	1.18	1.1
M.....	1.4	1.5	1.45	1.4
U. Q.....	1.7	1.8	1.98	1.7
No. observations.....	61	29	4	94
J: L. Q.....	.9	.9	1.25	.9
M.....	1.2	1.2	1.8	1.2
U. Q.....	1.55	1.4	2.35	1.6
No. observations.....	60	28	3	91
K: L. Q.....	.8	.9	.8	.8
M.....	1.0	1.0	1.0	1.0
U. Q.....	1.3	1.3	2.6	1.3
No. observations.....	84	10	1	95
L: L. Q.....	1.3	1.5	.....	1.3
M.....	1.6	1.8	2.4	1.6
U. Q.....	1.9	2.15	.....	2.2
Total No. observations.....	638	352	95	1,086
Weighted } L. Q.....	1.03	1.10	1.21	1.04
Average } M.....	1.25	1.35	1.52	1.29
Measures } U. Q.....	1.59	1.64	1.99	1.66

following reasons: (1) The division into classes of 1 idea, 2 ideas, etc., is too coarse a grading, for 91 per cent. of the observations are found in the first and second classes. (2) The distribution according to the number of ideas is skew, having a mode at 1 idea and tapering off to 4 or 5. (3) The distribution of the reaction times is skew, having a mode at 1.0'', a lower limit at .5'' and an upper limit at about 3.5''. (4) The 1,086 observations are not equally independent, being comprised of twelve sets of about 90 each, each set being the data for one individual.

Considering these objections in order: (1) This is an objection which cannot be overcome, but its effect will be to decrease any coefficient of correlation found, so that it will not be the cause of spurious correlation. (2) and (3) The fact that the distributions are skew does not in itself vitiate the use of a Pearson coefficient of correlation. A far more important consideration is that the relation shall be linear, which it is approximately. (4) In order to obviate this difficulty a coefficient of correlation can be calculated for each individual and the average of them will give the average correlation found. Calculation upon this basis gives the following results:

Observers	r 's
A.....	.204
B.....	.413
C.....	.250
D.....	.095
E.....	.123
F.....	.043
G.....	.340
H.....	.219
I.....	.154
J.....	.137
K.....	.038
L.....	.144
Average.....	.180
Probable error.....	.020

It is thus seen that the average correlation found is .18, with a small probable error of .02.

THE OBSERVERS

Before giving scholarship records a word as to the observers will be in order. The observers are all men with the exception of observer *C*. Observers *A*, *B*, *C*, *D*, *F*, *G* and *H* are either graduate students or have completed work for a Ph.D. degree. The others are all advanced undergraduates. Observer *E* is a Japanese student who has a good command of the English language. Observer *I* is a Russian and a linguist of very exceptional ability. He is gifted with a remarkable memory and is also exceptionally strong in mathematics, engineering, science and economics. Observer *H* is a keen student of philosophy and his grades in other scholastic subjects are perhaps considerably below his ability in them. This is also probably the case with some of the other observers. For reasons mentioned in the next paragraph the rankings in mathematics, science and foreign languages do not conform exactly with the grades received in these subjects; however, the rankings given are upon the basis of grades and are indicative of ability only in so far as are the grades received.

RANKINGS IN MATHEMATICS, SCIENCE AND FOREIGN
LANGUAGES

Mathematics, science and foreign languages were chosen because grades in these subjects are more accessible than is true of subjects less universally pursued. The grades recorded in the following table were taken from the registrar's records when possible. If the student's undergraduate work was done at some other institution equivalent grades at the University of Illinois were taken. In some cases this involved an estimate, which was based upon the student's own judgment of his ability and upon other available information in regard to equivalent grades.

Following is a table of grades and rankings. (A star indicates a change in the order of ranking from that of grading.)

	Mathematics		Science		Foreign Language	
	Grade	Rank	Grade	Rank	Grade	Rank
<i>A</i>	91	1*	91	4	87	6
<i>B</i>	81	7	88	6.5	94	2.5
<i>C</i>	93	3	94.2	3	94	2.5
<i>D</i>	88	5	95	2	84	8
<i>E</i>	83	6	88	6.5	89	4
<i>F</i>	90	4	93	1*	86.5	7
<i>G</i>	73	11.5	77	11	85	5*
<i>H</i>	73	11.5	80	10	83	9
<i>I</i>	84	2*	86.5	5*	98	1
<i>J</i>	80	9	85.7	8	69	12
<i>K</i>	80	9	76.5	12	72.5	11
<i>L</i>	80	9	82.2	9	77	10

In every case where the order of ranking has been changed from that of grading and an observer with a lower grade in a subject ranked ahead of some with higher grades, the change is amply justified because the lower grades are averages of grades received, in whole or in part, in advanced courses and the grades of the observers passed were received in more or less elementary courses. To illustrate: observer *I* with a grade of 84 in mathematics is ranked second, ahead of observers *C* and *F*, but not ahead of observer *A*. *I*'s grade is for advanced work in mathematics, as also is *A*'s, but *C*'s and *F*'s grades are for elementary mathematics. It is the opinion of the writer that the ranking given corresponds very closely with the ranking of these observers if determined according to grades received in identical courses in mathematics, science and foreign languages, but it is not thought that such grades would represent very accurately the abilities of the students in the subjects named for the reason that certain of them would make little effort to rank well according to grade. For example, *G* and *H* both receive grades around 95 in subjects which interest them and which they spend their time upon, and if *ability* in mathematics could be measured it is hardly likely that they would stand last.

TABLES

The following table gives rankings in all the preceding tests. The abbreviations at the head of the table have meanings as follows: Mathematics; science; foreign lan-

guages; (the remaining measures refer to the association experiment); median time of reaction; variability in reaction time, *i. e.*, the semi-quartile difference; recall of a particular situation; visual imagery; second articulatory imagery, *i. e.*, repetition in the use of reaction words; Alpha group; Beta group; Gamma group, as defined on p. 490.

TABLE OF RANKINGS

	Scholarship			Association Test							
	Math.	Sci.	F. L.	Time	Var.	Part. Sit.	Vis.	Second Art.	Alpha	Beta	Gamma
A	1	4	6	7	6	4.5	2	2	6	11.5	2.5
B	7	6.5	2.5	1	1	3	4	8	11	10	1
C	3	3	2.5	5.5	11	9.5	12	11	3	9	8
D	5	2	8	9.5	12	11	11	11	7	11.5	12
E	6	6.5	4	12	10	1.5	6	5	10	4	4
F	4	1	7	8	4	7	10	4	4	6.5	9
G	11.5	11	5	3	4	4.5	3	6.5	9	4	2.5
H	11.5	10	9	5.5	4	12	9	6.5	5	4	6
I	2	5	1	9.5	7	1.5	8	11	2	8	10
J	9	8	12	4	9	9.5	5	3	1	6.5	11
K	9	12	11	2	2	8	1	1	12	1	5
L	9	9	10	11	8	6	7	9	8	2	7

Following is a table of coefficients of correlation, calculated from the rankings in the preceding table:

	Scholarship			Association Test						
	Math.	Sci.	F. L.	Time	Var.	Part. Sit.	Vis.	2d Art.	Alpha	Beta
Math.....	1.	.....	.....	.....	.....	.....	.....	.....	.....	.....
Sci.....	.81	1.	.....	.....	.....	.....	.....	.....	.....	.....
F. L.....	.44	.31	1.	.....	.....	.....	.....	.....	.....	.....
Ass'n Time.....	-.31	-.34	.00	1.	.....	.....	.....	.....	.....	.....
Var.....	-.13	-.41	-.15	.60	1.	.....	.....	.....	.....	.....
Part. Sit.....	.25	.00	.60	-.18	.25	1.	.....	.....	.....	.....
Vis.....	-.31	-.71	.00	.41	.50	.22	1.	.....	.....	.....
2'd Art.....	-.18	-.34	-.44	.25	.50	.00	.48	1.	.....	.....
Alpha.....	.37	.37	.19	-.28	-.37	-.34	-.50	-.22	1.	.....
Beta.....	-.55	-.75	-.44	.08	.38	.00	.34	.37	-.31	1.
Gamma.....	-.22	.28	.22	.41	.55	.47	.65	.34	-.65	.22

In any square the coefficient of correlation given is that between the subjects indicated at the top of the column and the left of the row in which the coefficient occurs. These coefficients are comparable with Pearson coefficients of correlation, but were not calculated according to the Pearson

method. Spearman R -coefficients of correlation were calculated and transferred approximately into Pearson r -coefficients by means of the relation, $r = \sin (\pi/2 \cdot R)$. The probable error of a zero coefficient of correlation is .19. ($P.E._r = 1.5$, $P.E._R = 1.5 (.43/\sqrt{n})$).¹ If the correlation is as high as .40 we may feel certain that there is appreciable correlation and that the probable error is less than .19, but I cannot give a formula quantitatively expressing this. The formula $(1 - r^2) \cdot 19$ quite likely is not far from correct, but it lays no claim to either mathematical or empirical justification.

INTERPRETATION AND CONCLUSIONS

The small number of individuals studied necessitates that the results be constantly interpreted with reference to their probable errors. In the following work significance will be given particularly only to coefficients of correlation greater than .40, at which point the chances are about 10 to 1 that at least some correlation does exist.

Following is a restatement of the table on page 497 arranging subjects in the order of magnitude with which they are correlated with mathematics, science and foreign languages:

Mathematics		Science		Foreign Languages	
Sci.....	.81	Math.....	.81	Part. Sit.....	.60
F. L.....	.44	Alpha.....	.37	Math.....	.44
Alpha.....	.37	F. L.....	.31	Sci.....	.31
Part. Sit.....	.25	Gamma.....	.28	Gamma.....	.22
Ass'n Var.....	-.13	Part. Sit.....	.00	Alpha.....	.19
Second Art.....	-.18	Second Art.....	-.34	Ass'n Time.....	.00
Gamma.....	-.22	Ass'n Time.....	-.34	Vis.....	.00
Ass'n Time.....	-.31	Ass'n Var.....	-.41	Ass'n Var.....	-.15
Vis.....	-.31	Vis.....	-.71	Second Art.....	-.44
Beta.....	-.55	Beta.....	-.75	Beta.....	-.44

An inspection of these columns reveals the following facts:

1. The recall of a particular situation shows a positive correlation of .25 with mathematics and of .60 with foreign languages.

2. Reaction time and variability in reaction time are not strongly correlated with these subjects, though what correlation exists is negative and strongest with science.

¹ Whipple, 'Manual of Mental and Physical Tests,' p. 35.

3. Repetition in reaction words shows a slight negative correlation, especially with foreign languages.

4. Visual imagery is negatively correlated, especially with science.

5. The group Alpha (Synonyms, Coördination and Contrast) is favorably correlated with mathematics, science and foreign languages.

6. The Gamma group (Predicates, Coexistence and Subordination) is not materially correlated with these scholastic subjects.

7. The Beta group (Subject Relation, Object Relation and Causality) shows a pronounced negative correlation with all three subjects.

The reason for the existence of the tendencies noted is largely a matter of conjecture and the following are given as theories of explanation:

1. The recall of a particular situation is evidence of ability in a certain operation of memory. Excellence in foreign language demands a certain operation of memory. The high correlation between the recall of a particular situation and foreign languages indicates that the two operations of memory referred to are either the same or have some common factor.

2. No explanation for the small correlations found in (2) is attempted, further than to offer the theory that those able in science are rather slow but sure in their thought processes and therefore the tendency is to longer reaction times.

3. Repetition of words is considered by Jung and Riklin¹ as evidence of a limited vocabulary. Excellence in foreign language is closely connected with the possession of a large vocabulary. In explanation of the high correlation between foreign languages and the second Articulatory class (Repetitions) the theory is advanced that the mental condition in which there is difficulty in learning a foreign vocabulary is the same as, or intimately connected with, the mental condition in which the repetition of words in the association experiment occurs.

¹ *Journal für Neurologie und Psychologie*, 1903-04. Diagnostische Assoziation Studien.

4. Regarding the function of visual imagery: Some, at least, of the introspections exhibit visual imagery as a mediating factor in the association process, *i. e.*, a necessary link between stimulus and reaction; *e. g.*, observer *A*, No. 15, stimulus 'truth,' reaction 'u,' time of reaction 1.8", introspection "Strong visual image of the word spelled out. Search for a related word finally discontinued and reaction 'u' because of its vividness in the word 'truth.' There was no attempt to prevent vocalization of the letter, since I had no thought that it would not meet the condition of the experiment which requires that the reaction shall be a word." The introspection indicates that the visual imagery mediated between stimulus and reaction. A number of such reactions occurred. However most of the visual imagery can be explained as attendant imagery, *e. g.*, observer *B*, No. 71, stimulus 'habit,' reaction 'instinct,' time of reaction 1.7", introspection "Visual image of the natural history building, then of the physiological laboratory, then of the zoölogical laboratory at Chicago, then of an unbound copy of the *Journal of Animal Psychology*, then of an article, apparently by Yerkes, then Lloyd Morgan's book 'Habit and Instinct.'" In by far the majority of cases of visual imagery the association is less elaborate than the case just cited. The following is an illustration of a large class; stimulus 'beauty,' reaction 'girl,' introspection "I had a visual image of a beautiful girl." In such an association the belief that the visual imagery is merely attendant is less forced than in the illustration given immediately before, but there is little difference in principle between the two. If visual imagery is simply attendant to the process of association and is not in general a mediating factor then it is unnecessary and possibly a disturbing influence, and it may be that those without it spend that energy in more productive processes and therefore rank highest in scholastic work. This conclusion is in agreement with the finding of Galton that men of science are peculiarly lacking in visual imagery.

5. An analysis of certain of the fundamental conceptions of mathematics and science may reveal a reason for the

correlation of .37 between each of these subjects and the group Alpha (Synonyms, Contrast and Coördination). Such a conception as that of the surd roots of a quadratic equation involves the idea of coördination and contrast very explicitly. All conceptions involving inverse operations, *e. g.*, differentiation and integration, are definitely conceptions of contrast. Mathematical operations, such as solutions of equations, definitely involve concepts of equality or identity, which is very similar to the conception involved in the giving of synonyms. Considering the similarity of process in mathematics and in the comparison and contrasting of equivalent names, it is not surprising that there is a correlation between mathematics and the group Alpha, but rather that the correlation is not larger than is indicated in the table.

The high correlation between mathematics and science is in itself sufficient to account for most of the correlation between science and the group Alpha.

The correlation between the group Alpha and foreign languages, .19, is smaller than a consideration of the importance of synonyms in foreign language work would lead one to anticipate. A correlation coefficient, not shown in the table, between foreign languages and synonyms gives the correlation as .34.

The classification contains no group comparable to Jung's Definition class. Such a reaction as the following, stimulus 'father,' reaction 'chief of the family,' Jung¹ cites as belonging to the Definition class. His conclusions that the definition type of reaction is a simulated type and is evidence of low mentality, do not apply to the Synonym class in this experiment for the following reasons: (a) There would be few, if any, reactions found in the Synonym class in this experiment, which would precisely correspond to Jung's Definition class. (b) The postulate of simulation is a theory of explanation and not a fact of evidence. While simulation has been the subject of considerable investigation a definite criterion thereof is still lacking. There is no ground for the assumption that the reactions here classified as synonyms are simulated.

¹ 20th anniversary lectures of Clark University.

The results obtained in this experiment point to the fact that reactions with synonyms are correlated with a high type of ability in scholastic pursuits.

6. The Gamma group is composed as follows: 55 per cent. Predicates and Judgments of Quality; 33 per cent. Coexistence; and 13 per cent. Subordination. Things can coexist in a very large number of ways and, as already explained, the reactions were put into this class only when they could not satisfactorily be put into another. It follows that the reactions in this class are heterogeneous and high correlation between Coexistence and scholastic work could not be expected. The mental processes involved in naming predicates of an object are quite similar to those concerned in Subordination. The naming of predicates is neither a particularly difficult, nor a particularly simple task, but is quite colorless and on a more or less automatic level. Because of the nature of the three classes composing the group Gamma, one could anticipate only slight correlation of this group with scholastic attainments. The small correlations that the data yield are in this order: positive for science (where the importance of the naming of predicates is probably the most pronounced); positive, but smaller, for foreign languages; negative for mathematics.

7. The group Beta (Subject Relation, Object Relation, Causality) has only 8 per cent. of the total number of observations in it and is not considered as reliable as the Alpha group, with 31 per cent., or the Gamma group with 36 per cent. The description of the observations put into this group (see page 486) shows that in the mind of the classifier there is a close connection between this group and the class Phrase Completion. In other words it seems that the naming of an object when a verb is given, *e. g.*, 'hit'—'horse,' and the naming of a subject when the verb is given, *e. g.*, 'eat'—'boy,' is an association involving as little abstract thinking as a Phrase Completion association, when compared with the thought processes involved in a logical association, such as Coördination, Contrast or Synonyms. The correlation between group Beta and Phrase Completion is .15, with a probable error of .19 and if the data were more extensive a

decided correlation might be found. No great weight is placed upon the correlation found with this group, because of the known paucity of data, but nevertheless it is believed that such high negative correlations as it shows are significant of the general undesirability of the Beta group type of reaction.

8. Referring to the data upon the elaborateness of association we find a correlation of $.18 \pm .02$ between elaborateness of association and reaction time. Though this is probably too small, it gives a quantitative statement of the relation between these two things. This coefficient establishes beyond question that reaction time is a function of elaborateness of association. (Elaborateness is to be understood as here determined.)

The entire trend of this investigation points to the fact that (1) the free association experiment yields results which are indicative of the ability of the observers; (2) that the most significant features that are favorably correlated with scholastic rank in mathematics, science and foreign languages are (a) capability in the recall of a particular situation, (b) frequency of reaction with Synonyms, Coördination and Contrast; (3) that the most significant features that are unfavorably correlated are (a) frequency of visual imagery, (b) frequency of Repetitions, (c) frequency of reactions with Subject Relation, Object Relation and Causality; (4) that the data, as well as a consideration of the groups, suggest that the Alpha group (Synonyms, Contrast and Coördination) method of reaction involves greater ability than the Gamma group (Predicates, Subordination and Coexistence), which is in turn superior to the Beta group (Subject Relation, Object Relation and Causality) method.

In the treatment of the association experiment the means employed for determining the relation between the classes has certain recommendations which would be of particular importance in treating more extensive data. The use of any classification, such as Jung's, Wells', or the one here used, is open to serious criticism upon the ground that actual mental processes do not follow the logical lines laid down in the classification, and therefore the justification for a logical classification must lie in some manner within itself, *i. e.*,

in its inter-class relations, as well as upon its utility after having once been adopted and used. Aside from utility the prime essential of a classification is not that it shall be logically sound, but rather that it shall be capable of exact definition. If the various classes of a classification can be so definitely defined that a second experimenter, or the same experimenter at a later time, will classify a given set of reactions in the same way then the prime requisite of a classification has been met. By the method here used the inter-relation of the classes can be determined. As previously indicated, the relation between classes thus found is upon the basis of the strength of the tendency to react with a class *B* when the tendency to react with a class *A* is known. This method applied to data sufficiently extensive so that the various correlation coefficients plus or minus their respective probable errors do not overlap, would make it possible to arrange the classes in serial order upon the basis of the relationship between them; or, if this were not possible because the classes intrinsically are not related in a serial manner, it would make it possible to group the classes into such groups as they would naturally fall into and to definitely express the relation between these groups. With a classification, accurately defined as to the observations in each of the classes, and definitely determined as to the relationship between classes there is scarcely a limit to its usefulness in a large number of problems, *e. g.*, the determination of mental types, the determination of the correlation between various mental types and any other capacities that are capable of measurement (the present investigation giving a rough determination of the correlation between scholastic standing in certain subjects and certain types of association illustrates this use), the inverse problem, *viz.*: the determination of what subjects a student is best fitted to pursue judged by the results of the association experiment, etc. A great deal of good work has been done along the lines suggested, but much remains to be done. Foremost in this is the determination of a completely satisfactory classification and it is the writer's hope that the method here used will materially help in the solution of that problem.



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